ISSN 0018-151X, High Temperature, 2017, Vol. 55, No. 4, pp. 491–495. © Pleiades Publishing, Ltd., 2017.
Original Russian Text © A.L. Tukmakov, D.A. Tukmakov, 2017, published in Teplofizika Vysokikh Temperatur, 2017, Vol. 55, No. 4, pp. 509–512.

PLASMA INVESTIGATIONS

Dynamics of a Charged Gas Suspension with an Initial Spatially Nonuniform Distribution of the Average Dispersed Phase Density during the Transition to the Equilibrium State

A. L. Tukmakov[a], * and D. A. Tukmakov[b], **

[a]*Kazan National Research Technical University, Kazan, 420111 Tatarstan, Russia*
[b]*Kazan Federal University, Kazan, 420008 Tatarstan, Russia*
**e-mail: tukmakov@imm.knc.ru*
***e-mail: tukmakovda@imm.knc.ru*

Received September 30, 2016

Abstract—Results of calculations are presented for the transition of a charged gas suspension from the initial nonequilibrium state with a spatially nonuniform distribution of the average density to a state with a uniform distribution of the average density and charge in a bounded volume. A numerical solution is obtained for the system of equations describing the motion of a polydisperse multirate and multitemperature gas suspension, the particles of which carry an electric discharge and create a self-consistent electric field.

DOI: 10.1134/S0018151X17030221

INTRODUCTION

Models of the dynamics of gas suspensions consisting of particles carrying an electric charge are used for describing a number of processes, including the sputtering of protective coatings on painted surfaces in an electrostatic field, as well as the synthesis of powder materials consisting of solid particles covered by a polymer layer on counter flows [1–3]. Models of electrogasdynamics of gas suspensions, in addition to applied significance, are used in describing self-organization phenomena in dusty plasma consisting of charged particles, the density of which is sufficient to create an electric field consistent with the time-varying spatial configuration of gas suspension [4]. In [5], complex plasma in which dust particles interacting with the surrounding plasma were added to the general background of ions, electrons, and neutral particles was considered; this leads to the appearance of new physical effects. In [6], experiments with thermal diffusion of dust moving from a dusty region to a region with pure gas were described. The dust spread was studied at different diffusion coefficients and particle charges, and the regime in which dust particles are self-organized in a toroidal structure was revealed.

In computations performed in this work, the carrier medium is assumed to be an electrically neutral gas in consideration of slow processes whose duration is long compared to the period of plasma oscillations [7].

EQUATIONS OF MOTION OF A CHARGED GAS SUSPENSION AND METHOD FOR THEIR SOLUTION

The medium is an electrically charged polydisperse gas suspension, the particles of which are under the action of aerodynamic drag force, Archimedean force, added mass force, and the force acting from the electric field that is created by the distributed charge of the gas suspension. Its motion is described using the system of dynamic equations of a polydisperse multirate and multitemperature gas suspension with the rate and temperature phase slip [8]. The system includes equations of motion of the carrier medium and disperse phase.

The motion of the carrier medium is described by a system of Navier–Stokes equations with allowance for the interphase force interaction and heat transfer:

$$\frac{\partial \rho_1}{\partial t} + \frac{\partial(\rho_1 u_1)}{\partial x} + \frac{\partial(\rho_1 v_1)}{\partial y} = 0,$$

$$\frac{\partial(\rho_1 u_1)}{\partial t} + \frac{\partial}{\partial x}\left(\rho_1 u_1^2 + p - \tau_{xx}\right) + \frac{\partial}{\partial y}\left(\rho_1 u_1 v_1 - \tau_{xy}\right) = -\sum_{i=2,n} F_{xi} + \sum_{i=2,n} \alpha_i \frac{\partial p}{\partial x},$$

$$\frac{\partial(\rho_1 v_1)}{\partial t} + \frac{\partial}{\partial x}\left(\rho_1 u_1 v_1 - \tau_{xy}\right) + \frac{\partial}{\partial y}\left(\rho_1 v_1^2 + p - \tau_{yy}\right) = -\sum_{i=2,n} F_{yi} + \sum_{i=2,n} \alpha_i \frac{\partial p}{\partial y},$$